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Sustainable energy production and consumption in Turkey: A review

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ABSTRACT

In this century, energy has been the driving force of the global economy and it will, for sure, continue to be one of the most important element for the sustainable socio-economic development for the coming centuries. Therefore, energy producers and governors have a vital duty to provide enough energy in good quality continuously with low cost for the sustainable development. The subject of energy production and energy politics in Turkey generally comes at first privilege. Ahead of the 21st century, Turkish energy diplomacy started to affect the future course of Turkey's relations with the Eurasian countries as well as the Western countries. This paper describes energy production and consumption strategies in Turkey and criticizes Turkish energy policies. If the present pattern of energy production and consumption in Turkey is maintained, there will be serious problems to meet future energy demands due to shortages of resources and low financial inputs, combined with the environmental care for the country. As a result, major components of Turkey's strategy for sustainable development should include changing the present energy production and consumption patterns, expanding energy sources and the structure of power production, and creating an energy structure that is less or not at all risky to the environment.

Contents

1. Introduction

The demand for energy increases rapidly with economic and population growth. Future energy markets are facing uncertainties arising from energy policies in general and environmental

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requirements in particular. These uncertainties cause dramatic changes in global and regional energy policies. The world energy map has been redrawn as a result of these dramatic changes that have taken over the past 17 years. The new energy map will affect the world's politics as it was used to in recent history.

During the Cold War years, Western world set their policy interests to access to oil supplies, especially those of the Middle East. They were concerned more about not losing control over Middle Eastern oil supplies. There were several conflicts in Middle East, from the initial Arab–Israeli conflict of 1947 and the first Iranian crisis of 1951–1952 to the Suez crisis of 1956 and the Arab–Israeli wars of 1967 and 1973, since oil reserves and resources are unfairly distributed.

At the end of the Cold War, the Western interest in the security of the oil supplies from the Middle East is reduced a bit but the oil reserves in the region make it unavoidable that any change around the region will still continue to draw world attention. This has indeed been a factor in the region's internal politics since the break-up of the Ottoman Empire alter the First World War [1]. Krapels [2] says, the Middle Eastern countries will not be allowed even to sort out their own rivalries without substantial Western attention and intervention because the oil costs in Western countries are too high. Before collapsing of communism in Europe and the former Soviet Union, Western countries were not hesitating to enter a war in order to keep the oil fields in Middle East, but were ignoring the rich oil and gas fields in ex-Soviet countries [3].

After collapsing of communism in Europe and the former Soviet Union, world geopolitics and energy map apparently changed. Now that nearly 17 years have elapsed since the collapse of the Soviet Union, the unknown enormous land of Eurasia started to enter strongly to the global scene with its energy resources. The region covers more than twice the territory of the Middle East and forces a change in the worlds' traditional views on the energy scenarios. The Caspian Sea, the world's largest lake covering 600,000 km^2, is growing into a major oil and natural gas producing region. Another formation crosses the Northern Caucasian Mangeshlak plate, encompassing the fields of Azerbaijan and Turkmenistan and stretching to the Ai-al Sea [4].

The fields of the Kazakhstan, Azerbaijan and Turkmenistan hold lots of oil and rich reserves of natural gas. Today the sources in these countries are connected to Europe with a new pipeline crossing Turkey and Eagan Sea. This showed that Turkey has an important role on the middle of the strategically important region called Eurasia. Where might Turkey's role be found in the complex energy picture of the Eurasian world? Turkey started to have a vital importance on western energy politics because it is at the geo-center of the Eurasian world and in the center of strategic energy transportation paths. Thus Turkish energy policy started to play a crucially important role in all energy trade between the suppliers in Eurasia and the consumers in Europe.

The countries in the Caspian region wants to sell their oil and gas to the European markets. The capability of Turkish energy diplomacy in planning feasible policies will affect strongly the future pattern of Turkey's relations as an authority between the Western and the Eurasian countries [1]. This paper describes energy production and consumption strategies in Turkey and criticizes Turkish energy policies.

2. Turkey's energy history

Turkey is one of the major oil and gas importers for its own consumption. There are several primary energy sources in Turkey such as pit coal, lignite, asphalts, crude oil, natural gas, uranium, thorium called fossil energy reserves and also endless energy sources as hydraulic energy, geothermal energy, solar energy, see wave energy, biomass energy. Turkey's fossil sources especially fluid fossil fuel level is not enough compare constantly use in the world. Reserves of coal, geothermal and hydraulic energy potentials are 1% of the world.

Before the Republic of Turkey, energy production and consumption level stayed very low. First years of the republic, energy was used for heating more than industrial needs and the kerosene was used for lighting. In the first and second 5 years of development plans were prepared for the period of 1933 and 1942 targeting an increase in energy production to decrease outer dependency and to save the currency. In these periods, foreign companies producing coal were nationalized. Institute of mining technique (MTA), Etude management of Electric works, Eti mine works (Etibank) and Petrol Ofisi was established. In Turkey, petrol was found for the fist time at this period in 1940 by MTA.

Liberalism in fifties, interference of substructure gained and hydraulic and thermal centrals were planned to be built. Energy production and consumption increased depending on industrialization and economic growth, in the meantime energy consumption constantly increased at industrial areas. State water works (DSI), Turkey petrol association (TPAO), Atomic Energy foundation and Turkish Coal association (TKI) were established in this period. Hydraulic centrals of Sarıyar, Seyhan, Kemer, Göksu and thermal centrals of Tunçbilek and Soma were established from 1956 to 1959. Turkey passed to systematic development period in 1963. Hydraulic energy sources and energy efficiency became more important in first (1963–67) and second (1968–72) 5 years' development plans. Turkish Electric Corporation (TEK) was established in 1970. In third 5 years development plan (1973–77), duty of getting the necessary electrical energy constantly and effectively is given to the TEK. In this period, another corporation called YSI for general management of roads, water and electrical works is founded and energy and natural sources ministry was established. In third 5 years development plan, Keban hydraulic central (1974) and Seyitömer (1973), Hopa (1973) and Aliağa (1975) thermal centrals were opened. Besides all these developments in third 5 years period, energy demand was not compensated because the primary energy sources such as coal and water was not developed enough to cover demand.

At fourth 5 years development plan, the target for compensating the total energy consumption from product primary energy sources was set to 53%. In this period, the total energy product increment rate gradually decreased while the consumption rate was increasing gradually. At the end of 1977, almost half of the energy demand was compensated from energy produced with national sources.

Production of the primary source of energy was increased from 14,493 Btep to 27,687 Btep between 1970 and 1997. In this period production of lignite increased 6.8 times providing the biggest contribution. Product of lignite was increased to 11 759 Btep in 1997 and covering 42.5% of the total production. The rest of the energy production was obtained from wood 19.9%, petrol 13.1% and hydraulic energy 12.4%. Local product of petrol from 1971 to 1990 stayed under the level of 1970; however, in 1990 product exceeded 1970's production. Again after 1995 the product of petrol stayed under the level of 1970. Natural gas is used in producing energy in 1976; geothermal energy from 1984 and solar power from 1986 were added to local production sources from 1970 to 1997. Because of the differences between energy production and consumption, the percentage of compensating the energy demand was reduced from 76% (1970) to 38% in 1997 [5]. Then the government decided to put more investment on energy production but the contribution of private sector was very low. Still energy production could not compensate the demand.

Table 1
Development depend on plan periods, increasing of the energy production and consumption [6].

Periods	GSMH increase (%)	Primary energy production increase (%)	Primary energy consumption increase (%)
1. Plan period (1963–1967)	6.6	6.9	5.5
2. Plan period (1968–1972)	6.3	1.9	7.4
3. Plan period (1973–1977)	5.2	1.9	7.3
4. Plan period (1973–1977)	1.7	2.7	3.8
5. Plan period (1979–1983)	4.7	4.0	6.5
6. Plan period (1985–1989)	3.5	0.9	4.4
7. Plan period (1996–2000)	3.5	1.3	4.5
8. Plan period (2001–2005)	6.7	1.2	6.1

In 1990, natural gas production, which provides 0.7% of total primary energy production, has increased to 2.3% because of natural gas discoveries in Trakya area as Sevindik-1 and Göçerler-1. In year 2000, production of pit coal and lignite were 14.6 million ton equivalent petrol (MTEP) providing 53% of the total production. Petrol and natural gas took second place with 12.9 %. The rest were geothermal and hydraulic energy, and biomass and solar power [6].

Primary energy production and consumption increase rates in each development period from 1963 to 2000 are given in Table 1 [6]. As seen in this table, energy consumption rates are always higher than production except for the first development period. This was the main reason for energy crisis.

3. Energy consumption of Turkey

Total primary energy sources compensating the Turkey's energy demand reached 88 million Ton PEE (Tep) in 2004 and 93 million Ton PEE (Tep) in 2005. Energy consumption occurs mainly in primary energy sources such as petrol (18%), coal (27 %), natural gas (23%), hydropower (4.5%), renewable (7.5%), and noncommercial sources.

Rapid increase of energy consumption in Turkey is causing the energy sources to be more important. In 1927, the population of Turkey was 13,648,270. Between 1927 and 1970, the population of Turkey increased about three times to 35,605,176. The population is increased about two times from 1970 to 2007 (70,586,256 inhabitants), while energy consumption was increased more than four times per person in the same period. Although the energy consumption per person in Turkey is still under the average of the World and EU, the increase in energy consumption per person is considerably high compared to Western countries [7].

Since 1970, energy production pattern in Turkey changed dramatically. The energy rate produced from wood is reduced from 20.4% to 6%, rate of spoils of plant and animal is decreased from 11.3% to 1.6% and rate of petrol usage in energy production is decreased from 43% to 37% while natural gas contribution on energy production was increased from 0% to 20.6%. The natural gas usage means a rapid increase in imported energy sources rate in total consumption as seen in Fig. 1. While import sources rate were 17% in total consumption in 1970, it is increased to 47% in 1980, 52% in 1990, 68% in 2000 and 73% in 2005. Thus the rate of the domestic energy sources such as wood, spoils of animal and plant, hydroelectric and renewable sources were decreased dramatically which naturally need to be the dominant ones in total energy production. Since the major sources are imported and the energy production methods are not so efficient gross national product energy consumption reaches nearly 500 kg PEE/thousand euros in Turkey while it is nearly 200 kg PEE/thousand euros in EU. Because of these facts, energy production and consumption efficiency shown in Fig. 2 become one of the most important problems for Turkey's energy policy [8].

4. Turkey's energy sources

Turkey has five important primary energy sources. They are petrol, natural gas, coal, hydroelectric and renewable energy sources. There are several other primary energy sources such as fossil roots reserves (pit coal, lignite bitumen, crude oil, natural gas,

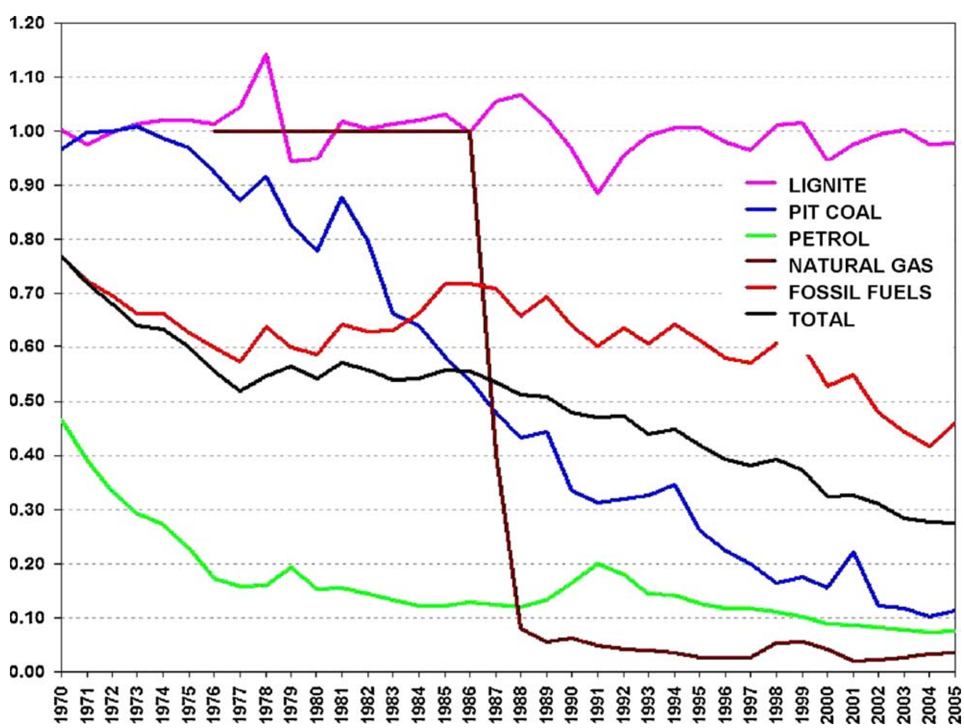


Fig. 1. Ratio of domestic energy production to total consumption in Turkey.

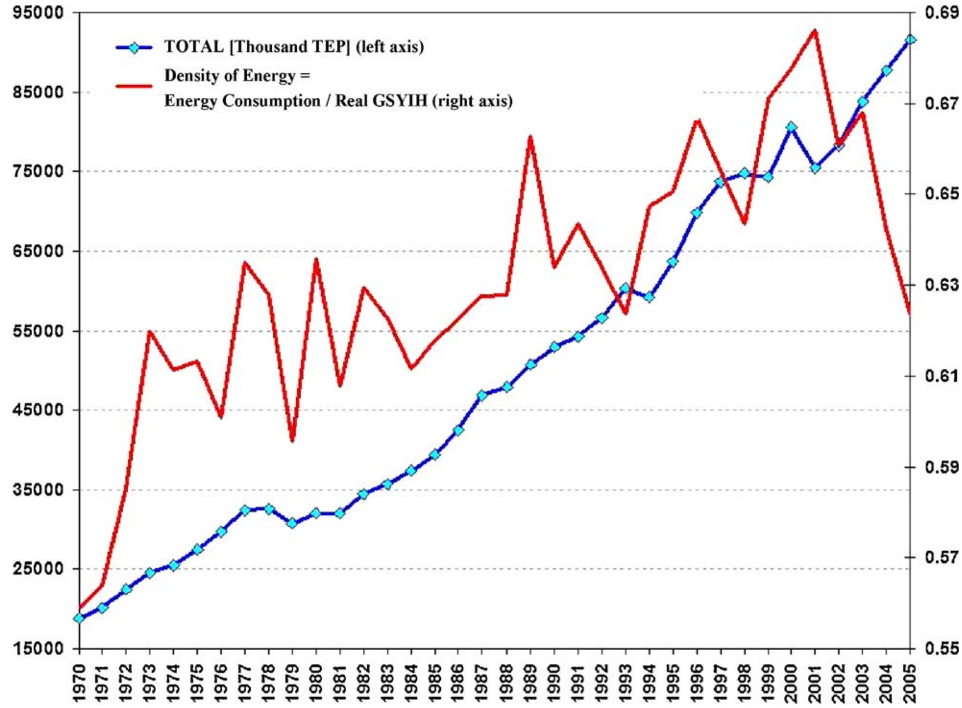


Fig. 2. Energy consumption and efficiency of Turkey.

uranium and thorium) and endless sources potential (hydraulic energy, geothermal energy and solar power). However, coal, geothermal and hydraulic energy reserve and potential is only 1% of the world sources.

At the end of the 2005 annual average of energy consumption in Turkey is 92.5 MTEP, at the end of 2006 total electric energy production was reached 175.7 milliards kWh. In this period the nationwide total energy demand (gross demand) was actualized as 174 milliards kWh. As seen in Table 2, in 2006 product of electrical power obtained 44% from natural gas, 25.1% from hydraulic, 18.4% from lignite, 6.3% from imported coal, 3% from fuel oil, 1.6% from pit coal and 1.1% from naphtha. 54.7 % of Turkey's electrical power production was obtained from imported sources in 2006 while 74.7 % of the domestic sources were obtained from thermic centrals [9,10].

4.1. Petrol

Petrol searches were started at the beginning of Turkish Republic in 1923 and first production plant was opened in Raman in 1940. Then Garzan field has followed Raman in 1951. Right now 16 foreign and 3 domestic companies still searching for new sources of petrol. Till now 2834 trial were made and 95 natural gas fields and 17 petrol fields were discovered. Crude oil reserves are about 43 million ton in Turkey. The production in 2005 was realized as 2.2 million ton. Since most of the petrol demand is important, the energy policy in recent years is changed to decrease the dependence on petrol by using other energy sources. Although there is target of reducing the dependence on petrol lower than 40% in 10 years, new investment on petrol searches is still very important. Turkey petrol's and anonym association (TPAO) is working on petrol searching in the country as well as the surrounding seas [11].

Table 2
Production levels in 2006.

	Production (GWh)	Production part (%)
Fuel-oil	5.324	3.0
Diesel fuel	0.18	Less than 0.1
Pit coal	2.855	1.6
Import coal	11.055	6.3
Lignite	32.242	18.4
Natural gas	77.233	44.0
Geothermal	0.10	Less than 0.1
LPG	0.452	0.3
Naphtha	2.010	1.1
Biogas	0.39	Less than 0.1
Others	0.84	Less than 0.1
Hydraulic	44.154	25.1
Wind	0.129	Less than 0.1
Total	175.695	100.0

Petrol consumption of Turkey was reached to 31 million ton or 622 barrel/day yearly in 2005. This compensates only 7.1% of petrol consumption with existing reserves and production. Bakü-Tiflis-Ceyhan project which TPAO' partnership contributes compensates 1 million barrel/day petrol. Among all this sources, petrol reserves in the Black sea are becoming very important for Turkey as seen in Fig. 3 [12]. As seen in this figure, petrol reserves are mainly in south and north part of the country. TPAO target is to reach 300 thousand barrel/day in 2010 and 600 thousand barrel/day in 2020 petrol production by using the new petrol reserves which means 60% of Turkey's petrol demand may be compensated by internal production [11].

4.2. Natural gas

Turkeys' natural gas reserves are quite limited thus feasible capacity is very low. Total natural gas consumption reached 27-milliard m^3; production of natural gas was only about 800 million m^3 in 2005. Domestic production rate in total consumption is around 3%. To compensate this huge demand, Turkey started to import natural gas first from Soviet Union in 1985. From 1985, natural gas consumption has started to increase rapidly. Nowadays more than half of the consumption of natural gas is used in electric power production, 11% is used in manure industry, 17% is used in factories as energy source and 15% is used in housing and trade

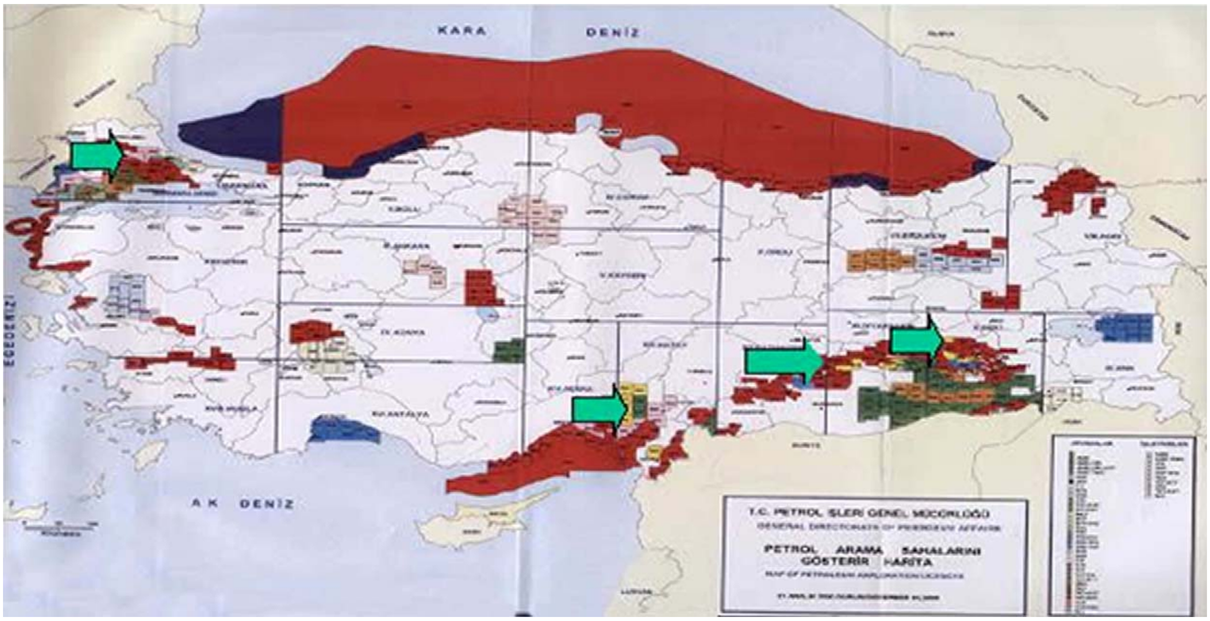


Fig. 3. Potential petrol areas in Turkey.

sector. Consumption rate was increased 15% from 1989 to 2005, and at the beginning of 2005, Turkey became 7th biggest consumer in Europe by using 5% of the total consumption of Europe.

Because of insufficient natural gas sources, Turkey compensates increasing natural gas consumption by importing 95% of the total demand from neighbor countries: 27 billion m^3 from Russia, 12.8 billion m^3 from west line, 4.9 billion m^3 from blue line, 4.3 billion m^3 from Iran, 3.8 billion m^3 from Algeria and 1 billion m^3 from Nigeria in 2005. In 2020 Turkey will have 50 billion m^3 natural gas consumption and 100 billion m^3 transport natural gas to Europe. So, Turkey will have 150 billion m^3 natural gas systems in 2020.

4.3. Renewable energy sources

Turkey has important potential for renewable energy sources such as wind energy, solar power and geothermal welded energy. Furthermore nuclear energy production has become an important energy source in recent years as well as solar power energy. Turkey's average sunbath time is 2640 h per day (daily total 7.2 h); average radiation volume is 1311 kWh/m^2 per year (daily total 3.6 kWh/m^2). Turkey's renewable energy potential is given in Tables 3 and 4 [13,14].

Solar power can decrease dependency on energy import and at the same time may enhance environmental pollution because of energy production. Wind energy potential in Turkey (over 83,000 MW) can theoretically compensate the total electrical power necessity. As is seen in Table 4, there is an expectant to evaluate high degree wind power potential existing in Turkey although right now only 2% of wind potential can be used. Turkey cannot use nuclear energy yet for energy production but three nuclear energy investments having 4.5–5 thousand MW production capacity each are will be finished until 2015 [15].

4.4. Hydropower

Hydroelectric potential in our country is nearly 1% of the world potential, 16% of the European potential. Nearly 65% of hydroelectric potential are still not converted to energy. Turkeys' theoretical hydroelectric potential with available water sources is calculated as 433 milliard kWh. Technically retable product potential is approximately 216 milliard kWh. Both the technical and economical retable producing potential is about 130 milliard kWh. Turkey is using only 46 kWh part of the hydroelectric potential by 2005. There are 142 hydroelectric central in total. Turkey has significant hydroelectric power resources especially in the Southeast Anatolia Hydropower and Irrigation (GAP) Project. There are 104 plants with installed capacity over 10.2GWGAP project. GAP includes 21 dams, 19 hydroplants and a network of tunnels and irrigation canals [16]. There are still nearly 400 project waiting to realize which will produce additional 11 milliard kWh. Thus usage rate of technical and economical potential will reach 45% in near future. 75% of the production capacity is produced in Keban, Karakaya, Atatürk, Altınkaya, Hasan Uğurlu and Oymapınar dams [15].

Table 3
Projection for electricity power in Turkey [13,14].

Fuel type	2000		2010		2020	
	Installed capacity (MW)	Generation (GWh)	Installed capacity (MW)	Generation (GWh)	Installed capacity (MW)	Generation (GWh)
Coal	7,465	38,186	16,106	104,040	26,906	174,235
Natural gas	6,756	46,217	18,923	125,549	34,256	225,648
Fuel oil	2,124	9,531	3,246	18,213	8,025	49,842
Renewable[a]	10,112	30,988	25,102	86,120	30,040	104,110
Nuclear	0	0	2,000	14,000	10,000	70,000
Total	26,457	124,922	65,377	347,922	109,227	623,835

[a] Renewable include hydropower, biomass, solar and geothermal energy.

Table 4
Turkey's renewable energy potential [15].

Renewable energy source	Gross (GWh/year)	Technical (GWh/year)	Economically available (GWh/year)	Usage (%)
Hydropower	430–450	215	100–130	30
Geothermal	16	8*	4**	22.5
Solar	365	182*	91**	4.5
Wind	400	124	98	62
Biogas	1.58	0.79*	0.4**	16.8

* 50% of the gross value is taken.
** 50% of the technical value is taken.

4.5. Geothermal

Geothermal energy is one of the most environmental friendly power sources that produce electricity with about one-sixth of the carbon dioxide that a natural gas-fueled power plant produces, and with small amount of the nitrous oxide or sulphur-bearing gases [17–21]. Geothermal energy has become popular at the beginning of this century during the energy crisis between 1973 and 1974 as seen in Table 5 [22].

Turkey has 170 number of geothermal area where fluids are over than 49 °C. Çanakkale-Tuzla, Kütahya-Simav, Aydın Salavatlı, Aydın-Germencik, Denizli-Kızıldere, Manisa-Salihli-Caferbeyli, İzmir Seferihisar, Dikili, and Denizli Gölemezli are suitable to produce electricity while the rest are suitable only for immediate usage as shown in Fig. 4 [21].

There are 51,600 housing equivalent heating is already available in Turkey and the thermal power reached 493 MWt. Furthermore totally 194 thermal springs are available for health tourism in Turkey corresponding 327 MWt. Right now Turkey is the fourth country using capacity situated in the world with 820 MWt. Proved thermal capacity reached nearly 2600 MWt. Probable geothermal capacity is about 31,500 MWt in Turkey. It means, in Turkey, 30% of the total houses (five million houses) can be heated by geothermal sources (equivalent to 32 billion cubic meters natural gas).

First electricity production by geothermal energy started in Denizli-Kızıldere area in 1974. Ten years later, a new plant established by TEDAŞwas added and the capacity reached 20 MWe. In 2005, the capacity was reached to 185 MWe and by building new geothermal electric plants, Turkey is planning to reach 500 MWe in 2010 and 1000 MWe in 2020 as seen in Table 6 [23].

4.6. Biomass, biogas and biofuels

Turkey's main renewable source is biomass and animal waste (67.4% of TPES) but expected to decline in share and absolute terms in the future as the convenience and options of oil, gas, coal, or electrical heating and cooking become available [24].

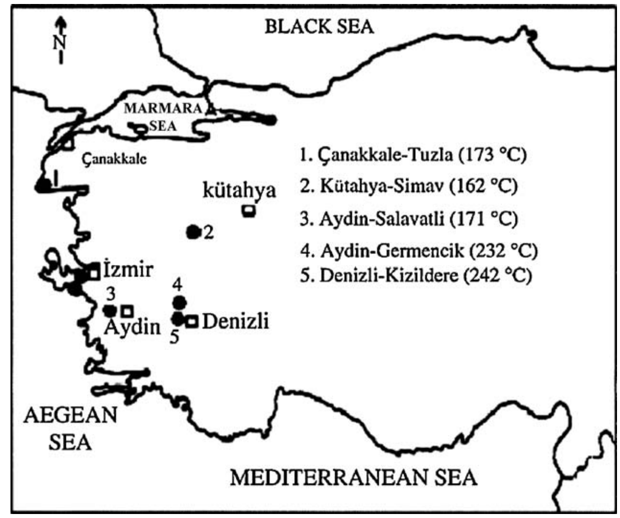


Fig. 4. Geothermal fields in western part of Turkey (over 100 °C) [21].

Turkey's total recoverable bioenergy potential was 196.7 TWh (16.92 Mtoe) in 1998 out of which 55.9 TWh (4.81 Mtoe) was from crop residues, 50 TWh (43 Mtoe) from forestry and wood processing residues, 48.3 TWh (41.6 Mtoe) from firewood, 27.3 TWh (23.5 Mtoe) from animal wastes, and 15.1 TWh (13 Mtoe) from municipality wastes [25].

4.7. Wind power

Wind energy is an alternative clear energy source compared to the fossil fuels [26]. The environmental impacts of wind energy production include site selection of the wind turbines in or near the flyways of migrating birds and wildlife refuges, electromagnetic interference with television and radio signals within 2–3 km of large installations, and noise of rotating blades [27]. Thus, wind farms must be built away from wild nature as well as residential areas. The wind turbines occupy only approximately 2% of the area. Most of the land can be used for farming such as vegetables, nursery stock, and cattle that is practical without the underground systems between the turbines [25].

In Turkey, the first wind power is obtained in 1998 near the city of Izmir. The system has 12 wind turbines for a total capacity of 7.2 MWe. By 2001, the number of the wind-powered plants reached 17. Turkey had a total installed capacity of 18.9 MW in 2002 [24]. The Ministry of Environment and Natural Resources has taken 72 new projects having a capacity of about 2000 MW into consideration. The full potential of wind power is about 20,000 MW in whole Turkey if all sources are used [28]. Scattering of wind potential and velocity in 10 m high are shown in Figs. 5 and

Table 5
Usage of geothermal power in World.

Year	Installed energy		Number of countries	Participants
	MWe	GWh/year		
1940	130		1	Italy
1950	293		1	Italy
1960	386	2600 estimated	4	+NZ, Mexico and USA
1970	678	5000 estimated	6	+Japan and USSR
1975	1310		8	+Iceland, El Salvador
1980	2110		14	+China, Indonesia, Kenya, Turkey, Philippines and Portugal
1985	4764		17	+Greece, France and Nicaragua
1990	5832		19	+Thailand, Argentina and Australia, −Greece
1995	6797		20	+Costa Rica
2000	7974	49,262	21	+Guatemala and Ethiopia, −Argentina

Table 6
Targets in geothermal power in Turkey.

Year	Capacity (MW)	Electricity generation (GWh)	Number of fields	Participants
2000	20	90	1	Denizli-Kizildere
2001	45	202.5	2	+Aydin-Germencik
2002	45	202.5	2	
2003	80	360	4	+Canakkale-Tuzla, Aydin-Salavatli
2004	100	450	4	
2005	185	832.5	9	+Kütahya-Simav, İzmir-Seferihisar, İzmir-Dikili
2010	500	2250	9	
2020	1000	4500	9	
2025	1250	5625	9	

6 [29]. Table 7 gives wind energy potential of Turkey in different regions [30].

4.8. Solar energy

Solar thermal receivers have several impacts on environment such as the degradation of soil quality caused by sodium chloride, contamination of the adjacent soil and groundwater with salt and potential release of toxic chemicals used in the heat transfer system [31]. Since the toxic chemicals such as cadmium sulfide and gallium arsenide are highly toxic and persist in the environment for centuries, disposal and recycling in inoperative cells is the major problem of using solar energy systems.

Solar energy has significant potentials for future energy demands of Turkey with its average annual sunshine duration of 2610 h and an average solar intensity of 3.6 kWh m^{-2} day^{-1}. As Turkey lies near the sunny belt between 36 and 42°N latitudes, most of the locations in Turkey receive abundant solar energy. Average annual temperature is 18–20 °C on the south coast, falls down to 14–16 °C on the west coast, and fluctuates 4–18 °C in the central parts [32]. Residential and commercial sectors, especially in the southern and western regions had an installed flat plate collectors of 750 ha in 2001 but only for solar heating. Usage of solar energy is expected to increase to 0.11 Mtoe by 2020 [15].

Table 7
Wind energy potential of Turkey in different regions [30].

Region	Annual average wind speed (m/s)	Annual average wind density (W/m^2)
South-Eastern Anatolia region	2.69	29.33
Mediterranean region	2.45	21.36
Aegean region	2.65	23.47
Middle Anatolia region	2.46	20.14
Eastern Anatolia region	2.12	13.19
Marmara region	3.29	51.91
Black Sea region	2.38	21.31
Average	2.58	25.82

4.9. Fossil energy sources

Coal is the main energy source by 24% of the total sources in Turkey. It has been used mainly for power generation, cement production, and steel manufacturing [7]. Turkey is one of the biggest producers of lignite in the world. This comes predominantly from deposits of the southwest and the Southeastern Afsin-Elbistan Basin, where 7339 million tons lignite is economically usable. The biggest lignite deposits (40% of the total) are in Elbistan [7]. The government plans to increase the coal supply from 20.1 Mtoe in 1999 to 118.4 Mtoe in 2020. It is believed that domestic lignite production will be almost tripled. The amount of fossil energy resources in Turkey is shown in Table 8 [33].

4.10. Coal

Lignite reserves are about 8 milliard ton and pit coal reserves are about 1.3 milliard ton in Turkey. Domestic coal production in 2004 was 48 milliard ton and importing realized as 16 milliard ton. Electric production potential that depends on lignite sources of Turkey is 120 milliard kWh/year, still 42 milliard kWh/year (approximately 35%) of this potential is under evaluation [34]. Share of coal in primary energy production since 1983 is given in Fig. 7 [35]. Lignite consumption started to reduce after 2000 as seen in Fig. 8 [35].

4.11. Lignite, asphaltite, bituminous schist and peat

8.2 milliard tons lignite, 1.3 milliard ton bituminous coal, 81 million ton asphaltite and 200 million ton peat reserves are

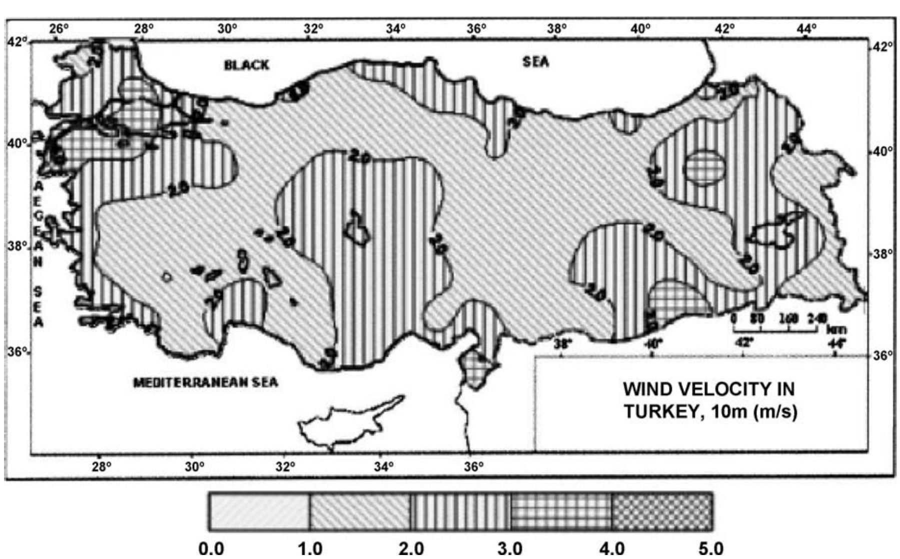


Fig. 5. Scattering of wind velocity in 10 m high for Turkey [29].

Table 8
Fossil energy sources in Turkey [33].

Sources	Apparent	Probable	Possible	Total
Hard coal (million tons)	428	449	249	1126
Lignite (million tons)	7339	626	110	8075
Asphaltite (million tons)	45	29	8	82
Bituminous schist (million tons)	555	1086	269	1641
Oil (million tons)	36	–	–	36
Natural gas (billion m^3)	8.8	–	–	8

available in Turkey. In 2000, 64.5 million tons of lignite is produced and it was approximately 85% of this production obtained by Turkish Coal Company. Lignite coals' economical value as raw material for producing energy is 2 milliard USD. Lignite coal is also widely for electric production and compensates about 34% of the total production [28]. Bituminous schist that is commonly used as thermal central fuel and synthetic petrol production by distillation has approximately 1.1 milliard ton reserves. It is available in seven areas as Beypazarı, Seyitömer, Göynük, Ulukışla, Mengen, Bahçecik and Burhaniye. Average calorific rate of bituminous schist is 1000 kcal/kg [28,36].

5. Electricity production and consumption

Demand on electric energy in Turkey has been increasing dramatically for the last four decades by a rate of 11% per year. Despite of this remarkable increase in electric energy consumption in Turkey, electric energy consumption for per person (2200 kWh/year) is still under EU average (6500 kWh/year) while it is around World average (2500 kWh/year). Although the Turkish government is planning to reduce the growth rate to 8% gradually for the next 12 years, the electric energy consumption may have reached up to 242 billion kWh by the year 2010.

Projection demand on electric energy necessity of Turkey for 2020 is given in Table 9 [37]. According to "High Scenario" (8.2% demand increasing at yearly average), electric energy demand will increase to 500 milliard kWh in 2020. 96,000 MW of this demand will be compensated with the planned power plants. According to low scenario (6.3% demand increasing at yearly average) electric energy demand will increase to 406 milliard kWh and 80,000 MW situated power will be required.

Turkey may compensate the extra-required energy from of hydroelectric, natural gas and renewable sources. In case of using all hydroelectric capacity, maximum power would reach to 128

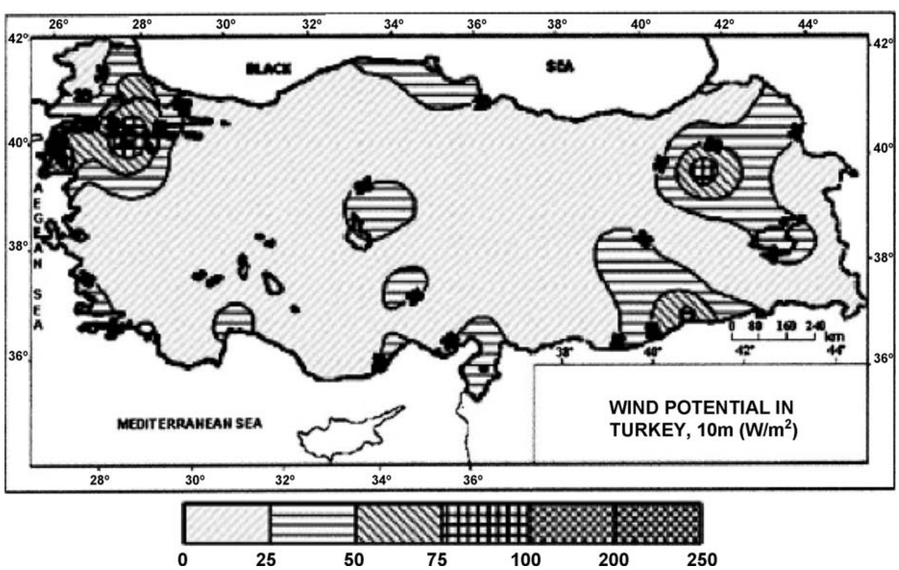


Fig. 6. Scattering of wind potential in 10 m high [29].

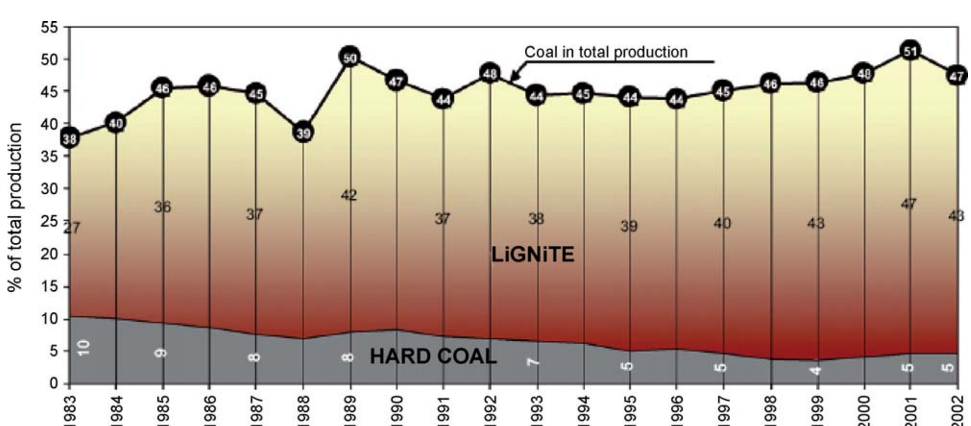


Fig. 7. Production of coal in primary energy production since 1983 [35].

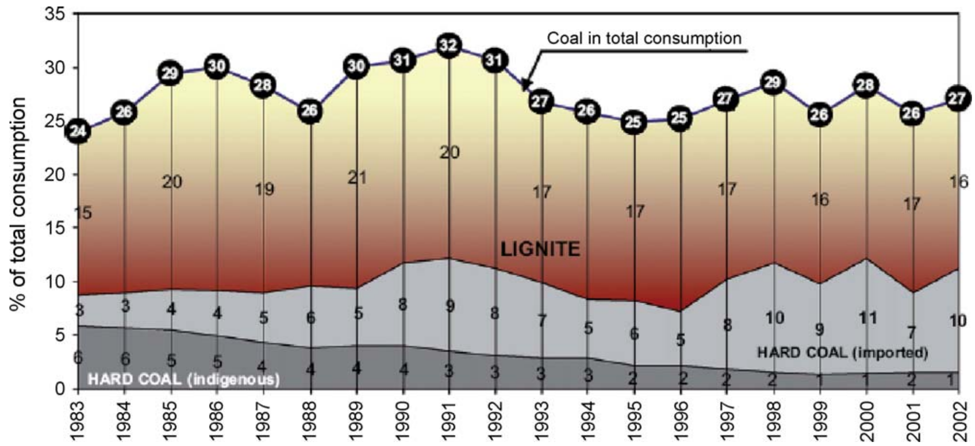


Fig. 8. Consumption of coal in primary energy consumption since 1983 [35].

Table 9
Electric energy projection demand [37].

	2005		2010		2020	
	Demand (Milliard KWh)	% Increase	Demand (Miliard KWh)	% Increase	Demand (Milliard KWh)	% Increase
High scenario	163	8.0	242	8.3	500	6.4
Low scenario	159	5.5	216	6.3	406	6.8

Table 10
Electricity productions from different sources [37].

Years	Natural gas	Coal	Hydropower	Other	Total
1990	10.192	20.181	23.148	4.022	57.543
1995	16.579	28.047	35.541	6.080	86.247
2000	46.217	38.186	30.879	9.640	124.922
2001	49.549	38.418	24.010	10.748	122.725
2002	52.496	32.149	33.684	11.071	129.400
2003	63.536	32.253	35.239	9.552	140.580
2004	62.242	34.447	46.084	7.925	150.698
2005	70.962	43.065	39.658	8.298	161.989
2006-(III)	78.500	45.200	42.000	8.300	174.000

milliard kWh. If all of the coal sources would be used it is possible to produce 120 milliard kWh electricity, with all natural gas sources the electric production may reach to 335 milliard kWh. As seen here, none of the scenarios can compensate the electric demand for 2020 [38]. The government is also planning to install 33 lignite, 27 natural gas, 12 coal, 2 nuclear, and 113 hydroelectric energy plants to compensate electricity demand [16].

At the end of 2006, 44.44% of electrical power is produced from natural gas, 29.39% from coal, 22.41% from hydropower and the rest are obtained from other sources as seen in Fig. 9. Table 10 gives chronological demand from 1990 till today. As seen in this table, coal and hydropower were the major sources up to 2000 but then natural gas which is mainly imported from abroad became the main source of energy production. The other renewable sources are generally used less than 10% in electricity production while there is an important potential of alternative sources in Turkey. Upgrading old coal-fired power plants may help to reduce coal consumption at coal-fired power plants for the same amount of electricity production, thus the coal sources may be used more efficiently.

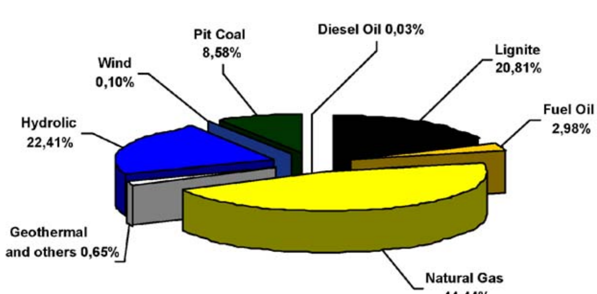


Fig. 9. Electrical energy production (Period IV in 2006) [37].

6. Existing energy politics

The energy politics are very important for improving people's living standards by socio-economic development. They are of critical importance to the national economy especially in the environment of a rapidly expanding economy like Turkey. Turkey's energy industry has to deal with both the dual pressures for economic development and the environmental protection. Energy politics of Turkey was declared as "providing sustainable energy for continuous economic growing, thus supporting social development by serving necessary energy in secure, reliable and economical conditions" by Energy and Natural Sources Ministry (ETKB) [37].

Turkey's energy needs are becoming such an important aspect of its foreign policy. Turkey is at the crossroads of several volatile,

strategically and economically important regions, including the awkward triangle of the Middle East, Central Asia, and the Caucasus. It is leading Turkey to friction with allies or neighbors, and Turkey should handle these problems with a proper energy politics. In recent years Ankara has made it an important policy goal to find and retain reliable energy supplies. Virtually all the necessary energy sources are available in the Caspian Sea basin's five states—Russia, Azerbaijan, Iran, Turkmenistan, and Kazakhstan. Most of the crude reserves are found in Azerbaijan. Kazakhstan has large natural gas deposits. In addition, Turkmenistan's western desert is believed to hold the world's second-largest natural gas stocks, estimated at about 21 trillion cubic meters. However, these countries already have sufficient domestic energy sources to meet their requirements. In contrast, Turkey has no significant internal resources thus it must build expensive pipelines to fulfill its needs. Thus Ankara has to take some decisions contrary to these other powers' policies and interests [39]. In the framework of this policy, Turkey's first and biggest step until now can be defined as Baku-Tbilisi-Ceyhan (BTC) crude oil pipeline project. Turkey with its partners finalized this project, despite many critics put forward lots of reasons that this project cannot be made. Today, with this project Azerbaijan and Georgia's dependency to Russia has decreased and Caspian Basin's oil can be carried easily via this pipeline. Turkey wants to increase its geopolitical importance and maintain its energy security by the construction of new pipelines such as Nabucco, Samsun-Ceyhan and Turkey-Greece-Italy pipelines [40].

Turkey's first steps in energy politics appear to have secured some success given the distance already traveled. She has not only accumulated some knowledge about the rules of the game, but she has become a player which is able, through sheer constancy and insistence, to persuade most of the other players to go her way. Turkey also realizes that it is rather a trek fraught with many pitfalls and deceptions. Still, the conviction that her policies and all the projects she is involved in are to the mutual benefit of all countries of the region as well as of the West as a whole, gives Turkey hope that her efforts are worth working on it says Temel Iskit in his article [41].

There are some local projects as well going on about sustainable energy, economical productivity and environmental issues in Turkey. New laws developed for adopting EU standards is decreasing government's role in energy quotation. The policies and regulations formulated by the Turkish Government for environmental protection, resource management, and energy management, such as the Energy efficiency and the Environmental Protection Law are of fundamental importance in entering EU. However, some regulations are still necessary for application to energy efficiency law and they should urgently come in to application [42].

Strategies and policies for sustainable development should be developed urgently. Education and capacity building for sustainable development is essential for the sustainable development of industry, transportation and communications. During these developments, protection of the atmosphere and environment is a must for Turkey before facing with unrecoverable environmental problems.

7. Conclusions

Energy is one of the most important strategic subjects for developing countries. Turkey is mainly depending on imported energy sources similar to the many countries in Europe. However, these countries give much more importance to renewable energy than Turkey. At the same time, the EU countries use Turkey as a bridge to carry energy source by using the pipelines between them and Turkey's neighbors where there is rich petrol and natural sources. This is an important advantage for Turkish energy policy if it is governed properly.

Turkey has an advantage of having almost all energy resources existing in the country. Unfortunately the resources except lignite and hydropower, are not still used efficiently to meet the needs of the country, and thus, an important part of the energy supply is imported. Renewable energy sources such as geothermal energy, biomass energy, solar energy, wind power and hydropower are the major resources available in the future. Although the geothermal industry is highly developed in Turkey, excellent geothermal sources still remain undeveloped since cost for a new natural gas plant is just half of a new geothermal plant. Usage of biomass energy to produce alcohol or other clean liquid fuels can be encouraged by utilizing biogas for daily life and commercial use. The technologies for both the direct and indirect use of solar energy should be implemented. Wind power can be used to provide electric power especially in remote areas. Obtaining electricity from insulated wind energy can be more effective by first converting to hydrogen energy. Development of large wind power generating units and stations may help reducing costs over the long term. Nuclear energy is necessary to install to an appropriate extent. Nuclear energy central's law should come in to force as soon as possible for variation of energy sources and according to gain new technologies. The development of small- and medium-scale sources of hydroelectric power, which have less impact on the environment and which are conveniently located near end-users should be accelerated. With these sources, domestic value should be increased in energy sector. Energy production that obtained from renewable energy sources should be improved by offering more attractive exhortations.

The overall objectives of the energy policy in Turkey should be achieving sustainable development in the energy industry and meet the needs of socio-economic development by strengthening the planning and management of energy systems; formulating and implementing a proper policy and regulatory system appropriate for the market economy; developing advanced, environment-friendly energy production and utilization technologies; increasing efficiency; reducing environmental pollution. The strategy and policies for the development of energy and the environment shall be primarily to improve the energy structure and distribution of energy. New sources of petroleum and natural gas shall be tapped. New and renewable sources of energy as local conditions allow shall be explored. Priority should be given to the development of renewable energy resources in the national energy development strategy by adopting appropriate financial incentives and market mechanisms. Finally, energy efficiency and the rational utilization of energy need to be improved while environmental pollution through the use of advanced technologies is less than the conventional methods.

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